Certification of Hardware for Photovoltaic Applications*

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ABSTRACT

A hardware certification program that helps deliver accurate, credible estimates of photovoltaic component and system performance is needed to enhance the image of the photovoltaic technology and to remove barriers to accelerating photovoltaic installations. The existence of well-established product listing procedures in standards (UL1703 for photovoltaic modules, UL1741 for inverters) has gone a long way to provide consumers and building and electrical inspectors with the necessary assurance regarding safety and installation requirements, but not system performance. Hardware certification progress and the steps being taken to establish testing protocols and ultimately an inverter certification program are presented in this paper.

1. Introduction

Photovoltaic power system applications and installations in the US are experiencing very rapid growth due to several recent unexpected events. Last year's rapid increase in the cost of conventional electrical power in California and the shortage of power resulting in rolling blackouts throughout the West have fostered new perspectives on energy production and use. Several states are now offering generous incentive and rebate programs to supplement electric power production through the installation of photovoltaic systems. Most programs currently pay some portion of the installed system cost on a $/kW basis. The photovoltaic system rating used to determine the incentive typically uses module nameplate or measured rating and does not consider system losses such as inverter efficiencies or degradation. Some programs are now considering an energy-based incentive ($/kWh produced). In both cases, some customers are now expecting their systems to produce according to a nameplate rating or the prediction of energy production. Purchase and installation of all photovoltaic systems will eventually be based on predicted or guaranteed energy production. Whether the energy prediction comes from the system installer, a public web page, manufacturers' specification sheets or the customers' calculations based on manufacturers' data, actual energy production for today's systems almost always falls short of expectations because of inadequate (sometimes overrated) hardware specifications or inadequate information on component performance.

2. Status

There is no complete photovoltaic product (component or system) certification program in effect today in the United States. Photovoltaic modules and inverters can be listed for safety (using UL1703 and UL1741), and PowerMark provides certification for the Arizona State University Photovoltaic Testing Laboratories (PTL) in support of the photovoltaic industry and Underwriters Laboratories through environmental tests that support listing and qualification of photovoltaic modules [1,2,3,4]. However, these qualifications do not yet provide all of the necessary and important performance information such as complete module rating or degradation information.

A certification program for small photovoltaic systems was recently implemented at the Florida Solar Energy Center (FSEC) and was accredited and certified in September 2001. The program will measure and certify the performance of complete photovoltaic lighting and home power systems (including photovoltaic modules, charge controller, batteries, loads, wiring, etc.) targeted for remote areas of the world. Additionally, domestic and international standards organizations have begun writing requirements for photovoltaic component and system certification [5,6,7].

The photovoltaic and balance-of-system industries often do not provide sufficient specifications or data to designers and customers to compute a true prediction of performance (and often the resulting reliability) for installed systems. Inverters are most often the component blamed for a system failure. Inverters also provide the critical link between the dc power produced and the ac to loads, but no method is established today for third-party certification of performance or operation, nor is there a published testing protocol or standard for determining inverter certification.

3. Inverter Certification: First Steps

A program to certify inverters for utility-interactive photovoltaic systems, including those that use energy storage to power critical loads when the grid is lost, is being implemented at Sandia National Laboratories under the US DOE National Photovoltaic Program as a first step toward certification of photovoltaic balance-of-system components [8,9]. As the inverter is the single most complex component of the photovoltaic system, and the critical link for delivered ac power, a fair number of tests beyond those conducted for listing and by manufacturers are needed to assure designers of the performance of inverters and to provide enough information to adequately estimate total system performance. The inverter certification must include tests to show maximum power tracking effectiveness, efficiency variations associated with power line voltage, environmental

effects, and losses that occur at night and during other protective shutdowns.

The hardware certification program will have several elements. They are:

- Determine characteristics to be evaluated or verified.
- Establish and verify test procedures for measuring or evaluating the hardware.
- Establish necessary qualifications for a testing laboratory.
- Establish an independent, certifying body to develop the laboratory requirements, verify compliance, and issue a certification mark.

Further, other considerations that must be taken into account for certification include:

- The need to certify hardware.
- The type of certification (hardware compatibility, performance, operation)
- The **Value** of further testing for certification.
- The **Costs** of certification. (**Value must exceed cost)** (Consensus now places high value on certification)
- The effectiveness of the certification results.
- The required accuracies. (It must be reasonable and affordable)
- The applicability of the certification results in all situations.

4. Photovoltaic Industry Participation

The first "Hardware Certification Meeting" was held in conjunction with Sandia's Photovoltaic System Symposium in July 2001 as a half-day event. More than 90% of the industry participants agreed that hardware certification was needed to level the playing field, to aid designers, to enable more accurate performance predictions and to boost consumer confidence in photovoltaic systems. One utility predicted the downfall of photovoltaic applications in his company if a certification program was not available. The major concerns for the certification program were cost and follow-up as products evolve, but many were willing to add up to 10% of product costs for certification.

This hardware certification program will provide the new documents and standards necessary to consistently test and evaluate hardware that will allow better predictions of system operation. The inverter test protocol will be jointly edited and reviewed by two important parts of the industry. A "User" working group and a "Manufacturers" working group have been established. These groups will participate in at least one meeting and email-based collaboration during 2002. A first-year goal is for Sandia National Laboratories to publish an inverter test protocol document for certification that has an industry consensus approval.

5. The Establishment of a Testing Facility

The establishment of a national testing laboratory and administration organization for hardware certification will require extensive test equipment and facilities. Because hardware certification does not appear to be a sufficient revenue stream to sustain a laboratory, a reasonable approach would be to establish the testing program using a nationally recognized facility that is diverse enough to provide part-time photovoltaic hardware certification. Short-term use of Sandia National Laboratories' established testing facilities with sophisticated equipment in place for a fee could provide a jump-start for the certification process.

6. Summary

More states and investors are stepping up the installation of photovoltaic systems but there is no complete certification for photovoltaic components and systems available today. A photovoltaic hardware certification program has begun. Participants will write a test protocol document for grid-tied inverters. The PV industry is active in the first steps of the hardware certification. The "Inverter Testing Protocol" will be published through Sandia National Laboratories in 2002. Other aspects of implementing certification testing are in the planning stages at Sandia.

7. References

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[4] *Crystalline silicon terrestrial photovoltaic (PV) modules - Design qualification and type approval*, IEC 61215 (1993-04).

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[6] *Solar Electric Power*, The US Photovoltaic Industry Roadmap, produced and printed by the US Photovoltaic Industry, April 2001.

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